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Gloeophyllum protractum is synonymous with *G. mexicanum*

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Abstract — *Gloeophyllum protractum*, a boreal polypore, is synonymized with the subtropical *G. mexicanum*. This taxonomic opinion is supported by sequencing of ITS and nuLSU regions. Morphology and ecology of this species are discussed.

Key words — *Basidiomycota*, *Gloeophyllales*, *Gloeophyllaceae*, molecular taxonomy

Introduction

The species of *Gloeophyllum* P. Karst. comprise a distinct group among polypores distinguished by a brown rot, tough dark brown context, and very variable (poroid, daedaleoid, or lamellate) hymenophore (Gilbertson & Ryvarden 1986). The six species (*G. abietinum* (Bull.) P. Karst., *G. carbonarium* (Berk. & M.A. Curtis) Ryvarden, *G. odoratum* (Wulfen) Imazeki, *G. protractum* (Fr.) Imazeki, *G. sepiarium* (Wulfen) P. Karst., and *G. trabeum* (Pers.) Murrill) known from Europe (Ryvarden & Gilbertson 1993, Niemelä 2005) are differentiated based on some critical morphological features and ecology, because the hyphae, hymenium, and spores are very similar in all species. In North America, these same taxa occur together with *G. mexicanum* (Mont.) Ryvarden (mostly on pines in subtropical regions and with *G. striatum* (Sw.) Murrill (a hardwood-specific, tropical species). Of the eight species found in East Asia (Dai 2012), seven are also found in Europe and North America and one (*G. imponens* (Ces.) Teng) is a tropical species growing on angiosperm wood (Dai et al. 2011, Dai 2012). All European species represent very common wood-inhabiting fungi except for *G. protractum,* which is very rare in Europe, limited to inner Scandinavia (Ryvarden & Gilbertson 1993) and some recently described localities in the Mediterranean region (Bernicchia et al. 2007, Tura et

al. 2010). In contrast, in the USA *G. protractum* is described as widespread from Florida to Alaska (Gilbertson & Ryvarden 1986) and is occasionally recorded also in East Asia (Dai et al. 2004, Dai 2012).

The unique phylogenetic position of the *Gloeophyllum* clade, separated from other polypores, was extensively studied by Garcia-Sandoval et al. (2011). Although many *Gloeophyllum* spp. sequences have been published, *G. protractum* is represented in GenBank by only one sequence, which is, however, identical with *G. odoratum* sequences. To clarify this issue, we sequenced variable rRNA regions of typical specimens of *G. odoratum*, *G. protractum*, and *G. mexicanum*.

Materials & methods

Specimens of *Gloeophyllum* were collected by the authors in Europe and USA or obtained from University of Helsinki herbarium, Finland (H). Our collected specimens are deposited in private herbarium of J. Vlasák (JV); some duplicates were also deposited in Prague Museum Herbarium (PRM).

Specimens examined: ***Gloeophyllum carbonarium***: **USA**, **Florida**, Everglades NP, pine, 29.VIII.2010, leg. & det. J. Vlasák (JV1008/67; GenBank JX266860, JX266862); Mahagony Hammock, pine, 21.XII.2003, leg. J. Vlasák Jr., det. J. Vlasák (JV0312/21.10-J; GenBank JX266861, JX266863).

Gloeophyllum mexicanum: **USA**, **Florida**, Everglades NP, pine, 29.VIII.2010, leg. & det. J. Vlasák (JV1008/67; GenBank JX266857); Big Cypress Nat. Preserve, Collier-Seminole State Park, 25.XII.2003, leg. J. Vlasák Jr., det. J. Vlasák (JV0312/25.14-J); Ocala, Ocala Nat. Forest, pine, 19.XII.2002, leg. J. Vlasák Jr., det. J. Vlasák (JV0212/35-J, PRM 860472; GenBank JX266856, JX266864).

Gloeophyllum odoratum: **CZECH REPUBLIC**, Hluboká nad Vltavou, Borek, spruce stump, 2.XI.2004, leg. & det. J. Vlasák (JV0411/2; GenBank JX266858, JX266859).

Gloeophyllum protractum: **USA**, **California**, Sierra Nevada, Tioga Pass, lodgepole pine, 18.VIII.2001, leg. & det. J. Vlasák (JV0108/100, PRM 860473; and JV 0108/101, PRM 860474; GenBank JX266850, JX266865 [sequences of both specimens identical]); **Oregon**, Crater Lake, pine, 15.IX.2007, leg. J. Vlasák Jr., det. J. Vlasák (JV 0709/135-J; GenBank JX266851, JX266852). **FINLAND**, **Inarin Lappi**, Inari, Lemmenjoki National Park, fallen charred trunk of *Pinus sylvestris*, 1.IX.1974, leg. & det. T. Niemelä (H 6012949; GenBank JX266853, JX266854); fallen decorticated trunk in dry site, 3.IX.1980, leg. & det. T. Niemelä (H 6012948; GenBank JX266855).

DNA methods

DNA was isolated and sequenced as described by Vlasák & Kout (2011). The evolutionary history was inferred by using the Maximum Likelihood method; the analyses were conducted in MEGA 5 (Tamura et al. 2011).

Results & discussion

We sequenced rRNA ITS region of several *Gloeophyllum mexicanum* and *G. protractum* specimens and one typical *G. odoratum* specimen. To root the phylogeny we used our sequences of *G. carbonarium* (considered closely related to *G. odoratum* by Garcia-Sandoval et al. 2011). Other *G. carbonarium,*

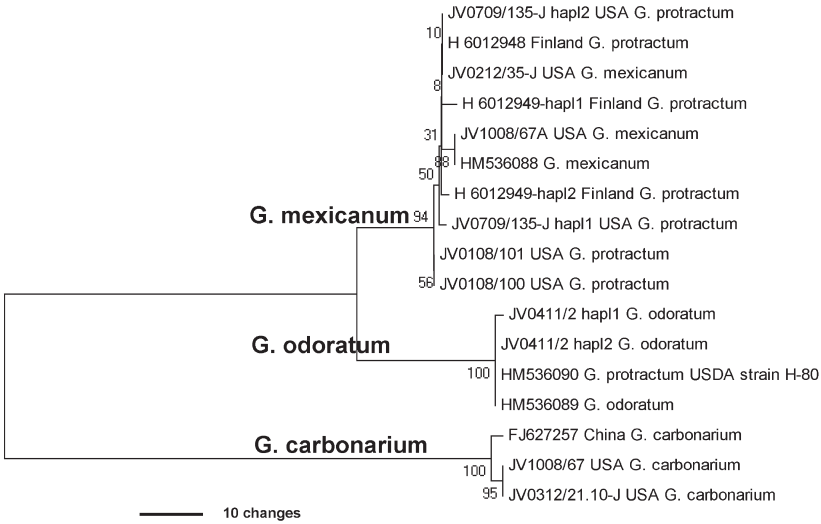

Fig. 1: Phylogenetic relationships of *Gloeophyllum* species inferred with ITS rRNA sequences. Sequenced specimens were determined according to their morphology; other sequences were retrieved with their names from GenBank. *Gloeophyllum carbonarium* was used to root the tree. Topology from maximum likelihood analysis. Support values along branches from maximum likelihood bootstrap. Branch lengths are drawn proportional to genetic distances (bar indicates 10 changes per ITS1-5.8S-ITS2 region). Some of the specimens show two haplotypes differing by short insertions/deletions. GenBank numbers indicate sequences retrieved from GenBank; other GenBank numbers in Materials & method.

G. mexicanum, and *G. odoratum* sequences were retrieved from GenBank. Alignment and simple analysis showed that the *G. mexicanum* sequences are identical with *G. protractum* sequences (Fig. 1). In particular, the *G. protractum* and *G. mexicanum* ITS sequences differ on average in only two positions, which corresponds to differences between individual *G. mexicanum* specimens or between different haplotypes in one collection. On the other hand, in *G. odoratum* approximately 10% of the positions differ from *G. mexicanum*/*protractum* sequences. The same result — identity of *G. mexicanum* with *G. protractum* and a pronounced divergence in *G. odoratum* — was obtained using nuLSU sequence analysis (not shown). The ITS2 region in one of two European *G. protractum* specimens had a unique insertion (4b) not present in the other specimen from the same locality. Accordingly, identity of European and American *G. mexicanum*/*protractum* specimens was also confirmed.

The name *Gloeophyllum mexicanum* [originally proposed in 1843 from Mexico as *Lenzites mexicana* Mont. (Montagne 1843)] has priority

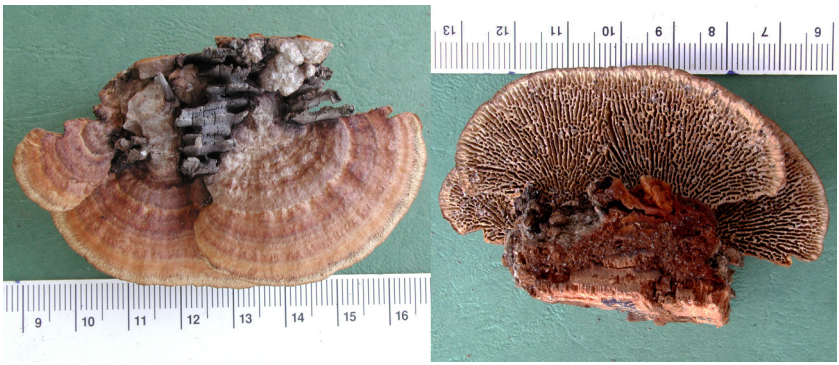

Fig. 2: *Gloeophyllum mexicanum* JV0212/35-J, Florida, typical, photo in collection.

over *G. protractum* [originally described in 1851 from northern Europe as *Trametes protracta* Fr. (Fries 1851)]. Gilbertson & Ryvarden (1986) separate *G. mexicanum* (Fig. 2) from *G. protractum* based primarily on the daedaleoid to lamellate hymenophore (which they describe as poroid to radially elongated in *G. protractum*). Nevertheless, in our collections both from California (Figs 3, 4) and Finland, one specimen had a more or less poroid hymenophore while the other from the same locality showed a daedaleoid to lamellate structure. We infer that this feature is not diagnostic. In other respects — especially in the glabrous to semi-glossy pileal surface unique in the genus as well as microscopically — the two specimens appear identical. Particularly, *G. mexicanum* is described as pileate polypore with sessile and broadly attached fruitbodies elongated along the substrate, 3–10 × 1–3 cm, ≤1 cm thick, mostly applanate, more rarely triquetrous, with upper surface at first finely tomentose but soon glabrous with a poroid to daedaleoid hymenophore, occasionally with few lamellae 8–12 per cm, trimitic hyphal system, and basidiospores 9–12 × 3.5–4 µm; *G. protractum* is described as a pileate polypore with sessile fruitbodies distinctly elongated along the substrate, 10 × 4 cm, 5–15 mm thick, often slightly triquetrous in section, with a glabrous to semi-glossy pileal surface when juvenile, pores entire to weakly elongated radially, 1–2 per mm, trimitic hyphal system, and basidiospores 8.5–11(–12) × 3–4(–4.5) µm (Gilbertson & Ryvarden 1986). The main difference is their ecology, with *G. mexicanum* regarded as a subtropical or tropical American species and *G. protractum* as boreal or alpine in Europe where it was described. In the USA, we also found the typically thick poroid *G. protractum* only in the Sierra Nevada at 3000 m a.s.l., not at lower elevations. But we believe that as it descends the fungus becomes more applanate and lamellate so that it forms a "typical" *G. mexicanum* fructification near the

Fig. 3: *Gloeophyllum mexicanum* JV0108/101, Sierra Nevada, Tioga Pass, determined originally as *G. protractum*, photo in situ.

Fig. 4: *Gloeophyllum mexicanum* JV0108/100, Sierra Nevada, Tioga Pass, determined originally as *G. protractum*, photo in collection.

southern USA border. Intermediate forms may be sometimes determined as *G. mexicanum*, sometimes as *G. protractum*, and this is the reason, in our opinion, why so many *G. protractum* finds are reported from lowland and southern USA (Gilbertson & Ryvarden 1986).

From the above descriptions, inspection of our own specimens, and molecular data we infer that the crucial features of *G. mexicanum* and *G. protractum* are in total agreement. We show that different ecology and associated differences in morphology need not result in species differentiation as now understood (Taylor 2000). Similar results were recently obtained with very variable American specimens of *Fuscoporia viticola* (Schwein.) Murrill analyzed by molecular methods (Vlasák et al., unpublished).

There is something odd also with two other *Gloeophyllum* species recorded from the USA: *G. odoratum* and *G. abietinum*. These extremely common European fungi are reported from only rather limited areas in the western USA (Gilbertson & Ryvarden 1986) in a region known for its phytogeographical uniqueness. We regard the distribution maps of *G. odoratum* as unreliable because *G. protractum* has probably been misidentified as *G. odoratum* in the USA. We were not able to find either species when we visited the putative areas of *G. odoratum* and *G. abietinum* occurrence in the USA.

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